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Determining the Most Sensitive Indicators for Each Species: A Cross-Species Comparison of Passerines

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Two key aspects of problem formulation in any ecological risk assessment of a contaminated site include choosing both the species to be evaluated and selecting the endpoints to be measured and used in risk characterization (EPA, 1992). Species should be chosen to be both representative of the ecosystem across multiple levels of ecological organization (such as classes of animals), and related in some identifiable way to the sources of contamination through the food web. The measurement endpoints (or indicators) chosen for assessment should be demonstrably sensitive to the ecosystem stressors in the species being assessed.

We evaluated multiple effects of environmental exposure to polycyclic biphenyls (PCBs) at superfund sites (and a reference site) on multiple organ systems (reproduction, endocrine, nervous system, immune system, gastrointestinal, skeleton, cardiovascular) as well as whole body in nestlings of five passerine species (eastern bluebird, carolina chickadee, house wren, red winged blackbird tree swallow) and assessed the pattern of endpoint sensitivity to the different species. Endpoints assessed included organ somatic indices (adrenal, brain, bursa, heart, kidneys, liver, lungs, pancreas, spleen, stomach, thyroid), skeletal measures (upper and lower beaks, femur, tibiotarsus, 3rd toe, humerus, radius, carpometacarpus) and asymmetries, brain measures (five forebrain measures and tectal lengths) and asymmetries, heart measures (width, length, depth), heart deformities, and body weight and length. Chemical analysis of PCBs was carried out on one nestling per nest box (or nest, for the red winged blackbirds). Statistical analysis (regression, general linear model-based ANOVA, and principal component analysis) was carried out using SAS, both on individual data and on nest-averaged data, using the paired nestling contaminant analysis as the indicator of exposure.

Based on the principal component analysis and the patterns of indicators which are significantly affected by PCBs, no passerine species had the same pattern of sensitivity to any of the indicator suites, nor was any single species the most sensitive to all of the suites of endpoints. The focus of this talk will be the patterns of responses evaluated using factor weightings (including all factor weightings above 0.3). Of the somatic indices, no species had identical patterns of factor weightings, and only the principal component factors for tree swallow was significantly correlated with PCB concentrations and TCDD toxic equivalents (TEQs). Tree swallow, red winged blackbird, and carolina chickadee primary factors of the skeletal impacts were all significantly related to PCBs and TEQs, but the patterns of effects of which indices were included in the principal component were extremely different, with only red winged blackbird having almost all indicators evaluated included in the principal component factors. Of brain measures, only carolina chickadee and and tree swallow principal components were significantly, or marginally significantly, correlated with PCB concentrations and TEQs, with more indices included in the principal component for chickadees compared to tree swallows, and a different pattern of sensitive indicators between the species. Bluebird and tree swallow heart formation (based on deformity metrics) were most sensitive to both PCBs and TEQs, but the tree swallows had all nine metrics included in the principal component, while only five of the nine metrics were included in the principal component for the bluebirds. Of heart measurements, the principal components for the tree swallows and red winged blackbirds were significantly correlated with PCBs and TEQs. Only tree swallow and carolina chickadee principal components for the brain measurements were significantly correlated with PCBs, and only the tree swallow principal component for brain measurements were significantly correlated with TEQs.

Of the species evaluated, tree swallow manifests significant responses to PCBs and TEQs across the

most endpoints in the systems evaluated. Carolina chickadee also manifest significant sensitivity to PCBs (and sometimes TEQs) across organ system and effects, but fewer metrics are significantly affected by contaminant exposure. While house wren and bluebird hearts are highly very sensitive to the effects of PCBs when considering teratogenic changes (deformities), other organ systems of these two species are less sensitive than other species to PCB-related contaminant effects. In sum, no single species is most sensitive to all of the effects of PCBs, or TEQs, and no single endpoint or suite of endpoints reflect the full range of contaminant effects on any given species. Thus, specific indicators to be evaluated in species at contaminated sites should be chosen based on the known sensitivity of the species present at the site, and not necessarily chosen because there is the largest literature on that indicator.

REFERENCES

US Environmental Protection Agency. 1992. Framework for ecological risk assessment. Washington, DC: Risk Assessment Forum, US Environmental Protection Agency.